Investigating Brain-Computer Interface Technology for NASA applications

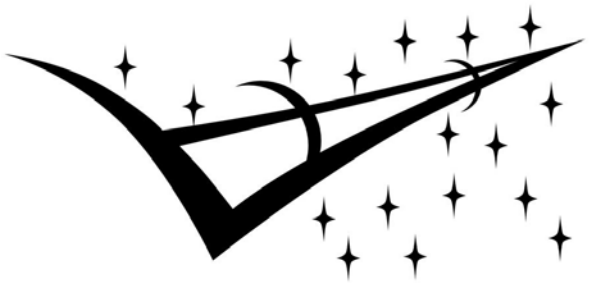
Brian Ramos

University of Rhode Island

Dr. Mihriban Whitmore

Habitability and Human Factors

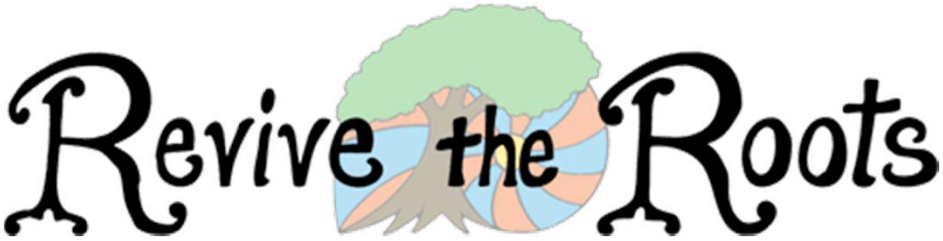
SPACE LIFE SCIENCES
SUMMER INSTITUTE



Who am I?

About Me

- University of Rhode Island
  - -B.S. Biomedical Engineering Degree
  - -B.S. Electrical Engineering Degree
  - -M.S. Electrical Engineering
  - -Bio-Neuro Brain Modulator



A NASA Intern

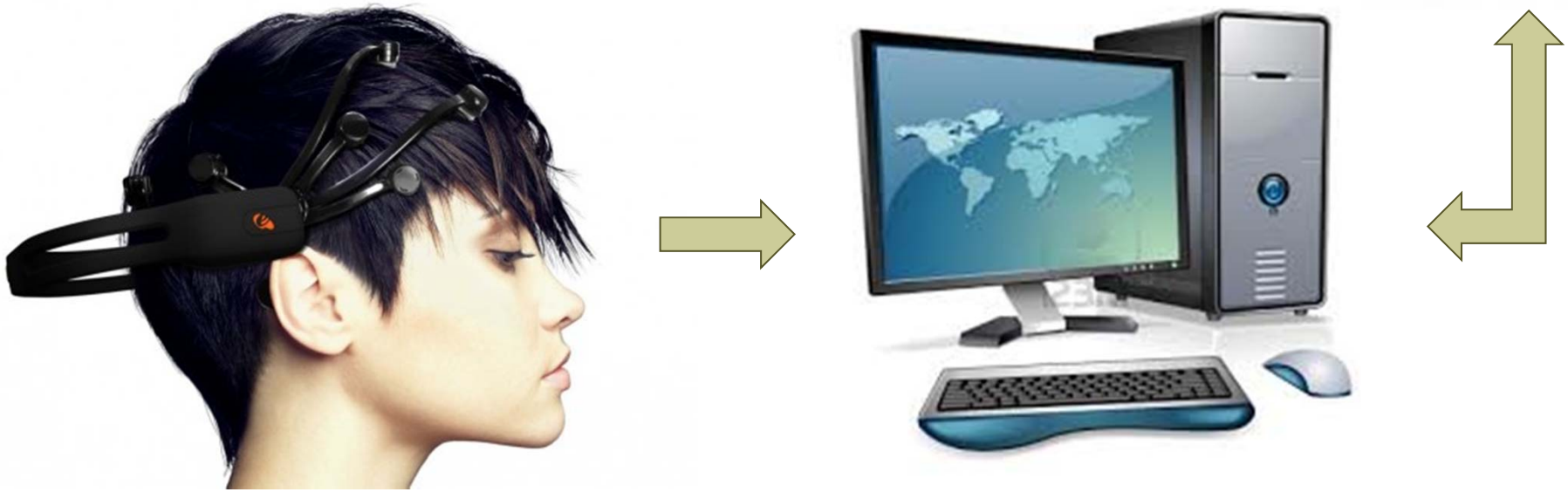
- DO5 Cargo Integration and Operations
  - Assembly Operations Handbook
  - MRM-1 Russian Research Module Schematics
- EA3 System Architecture and Integration Office
  - Design and Development Branch
  - Wrote LabVIEW control programs to control systems on board

Investigating BCI

- Exploratory Study on Brain-Computer Interface Technology (BCI)
  - IT labs alternative mode of control
- Electroencephalography (EEG)

  -Measures electrical activity along the scalp
- Brain-Computer Interface

  -Creates a pathway from the brain to a device



Investigating BCI

- Investigate Brain-Computer Interface Technology (BCI)
  - -Evaluate the feasibility of BCI's for use as a control system
    - -Human factors component
  - -Compare operation and efficiency of 3 various BCI headsets
  - -Collect raw brain-wave data on specific thoughts and emotions
  - -Use correlation algorithms to map thoughts to controls
  - -Integrate real-time data to control a quadcopter
  - -Create and document installation and testing procedures
  - -Think about other potential applications

Investigating BCI

NeuroSky®
Brain-Computer Interface Technologies

- 1 Electrode
- 512 Hz sampling rate

emotiv
you think, therefore, you can

- 16 electrodes
- 128 SPS

Cognionics

- 32 electrodes
- 128 SPS

Documenting

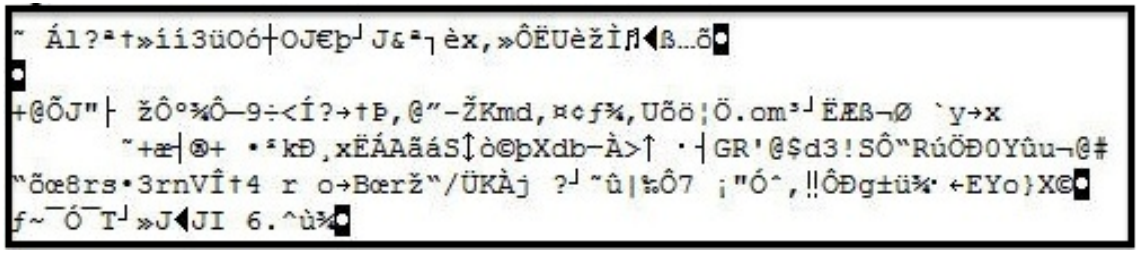
- Installation process
  - Skype calls
  - Avoid pitfalls
  - References to files and information
- Testing
  - Procedures and notes
  - Guidelines
  - How to process the data

Testing

- Mind Map Setup
- Directional
  - Neutral
  - Left, Right
  - Up, Down
  - 100 trials, 15 seconds each
- Emotional states
  - Anxious, happy, sad
  - Frustrated, concentrating
  - 50 trials, 15 seconds each

Handling Data

- Emotiv
  - CSV Converter
- Cognionics
  - MATLAB
    - Process multiple batches
    - Automatically add headers
    - Create file name of choice



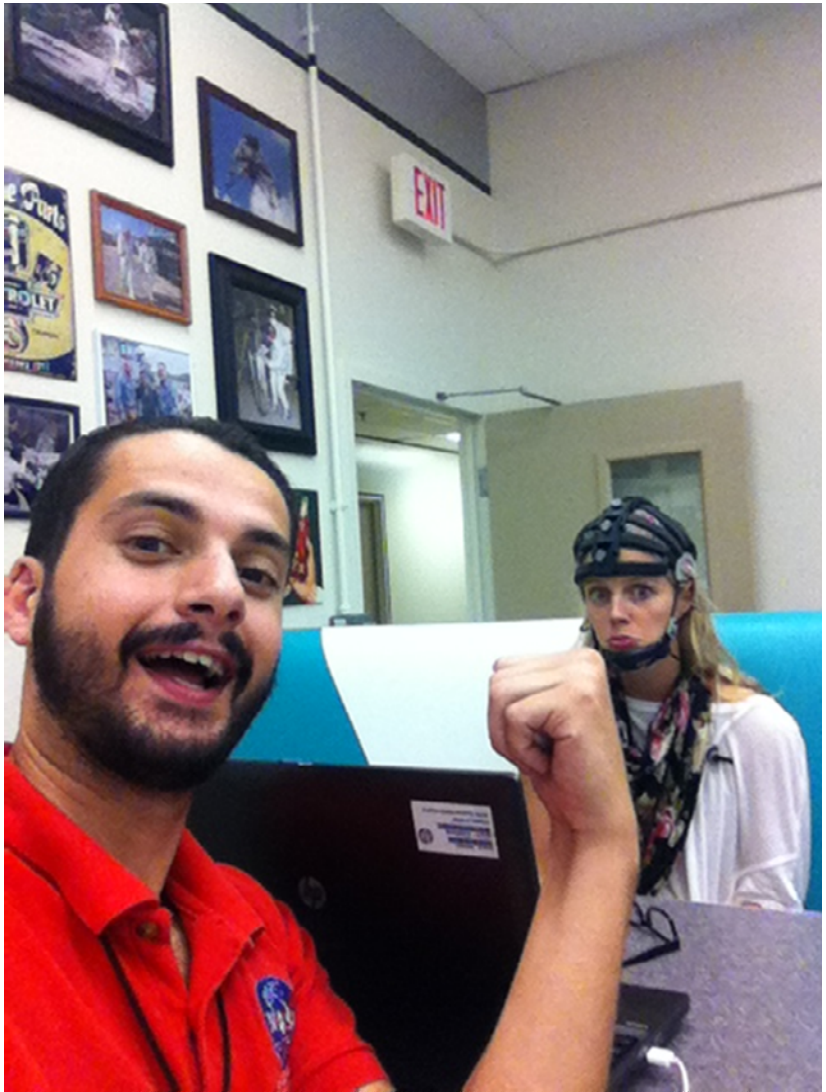
Editor - C:\Users\bramos\Documents\MATLAB\script.m

script.m | xlswrite.m | down7.cog

```
1   function [out] = cog_load(fname, EEG_CHS, EXT_CHS, ACC_CHS, notch)
2
3   %imput number of files and desired name of output file here
4   NumberOfFiles = 2;
5   XLFileName = 'Down1.xls'
6
7      for i=1:NumberOfFiles
8      fname = strcat('down', num2str(i),'.cog');
9   %fname = 'down1.cog';
10  EEG_CHS = 32;
11  EXT_CHS = 0;
12  ACC_CHS = 3;
13  notch = 1;
14  %System parameters to convert raw ADC units to physical units
15  VREF_EEG = 2.5;
16  GAIN_EEG = 3;
17  SCALE_EEG = 2^32;
18  ISTIM = 24e-9;
19  EEG_TO_VOLTS = 2*VREF_EEG/(GAIN_EEG*SCALE_EEG);
20
21  %Paramters of Aux Box v1
22  VREF_EXT = 4.75;
23  GAIN_EXT = 0.5;
24  SCALE_EXT = 2^32;
25  EXT_TO_VOLTS = VREF_EXT/GAIN_EXT/SCALE_EXT;
26
27  %Accelerometer based on ADXL327 at 2.5V supply
28  VREF_ACC = 2.5;
29  SCALE_ACC = 2^24;
```

Challenges

- Human Factors aspect
  - Test length and comfort, Noise issues, Sensitivity to mental state



Results

- Deliverables
  - Data sets
    - Over 300 Directional and emotional trials
  - Installation manuals
  - Testing procedures
    - » Estimates for setup
    - » Comfort levels
- Big Picture Contributions
  - Jump start
  - Challenges

Human Factors Risks

- Mitigate Risks for:
  - Tasks
    - -Mental states and fatigue
  - Training
    - -Feedback performance
  - Human-Computer Interactions
    - -Design interfaces to display information in a way that makes sense.

Moving Forward

- Use another program to access real-time data
- Neurosky data
- Collaborate with group in EV to integrate this data with their systems
- Run our data through analysis to try and find correlation between trials and directions
  - Polarized especially

Social Media to Gather Human Factors Information

- Can we get useful Human Factors information from social media?
  - Out of my element
  - Focus on Twitter
  - Reid Wiseman
  - Found sites to go back to day one (Topsy)
  - What's the best way to do this?

Adaptation, Equipment, and Training

Reid Wiseman
@astro_reid
Follow

First day on the job. Frustration was frequent in 0g! pic.twitter.com/Dlcz46cy4y

Reply Retweet Favorite More

Reid Wiseman
@astro_reid
Follow

Still adjusting to zero g. Just flipped a bag upside down to dump out the contents. #doesntworkhere

Reply Retweet Favorite More

RETWEETS 1,519 FAVORITES 2,001

6:15 AM - 3 Jun 2014

Reid Wiseman
@astro_reid
Follow

Two months in space. Floating is excellent but my brain still needs to visualize a ceiling, 2 walls, floor. Not fully there yet.

Reply Retweet Favorite More

RETWEETS 513 FAVORITES 1,113

6:38 AM - 23 Jul 2014

Procedure for Documentation and Recommendations

- Utilized a website to automatically archive tweets
- Export these to Excel
- Added formulas to automatically detect pull out timestamp and picture link
- Automatically make hyperlink
- Keywords / risks

- Social media could be a good tool
- Instagram for equipment and visual information
- Facebook, Tumblr

Knowledge Gained

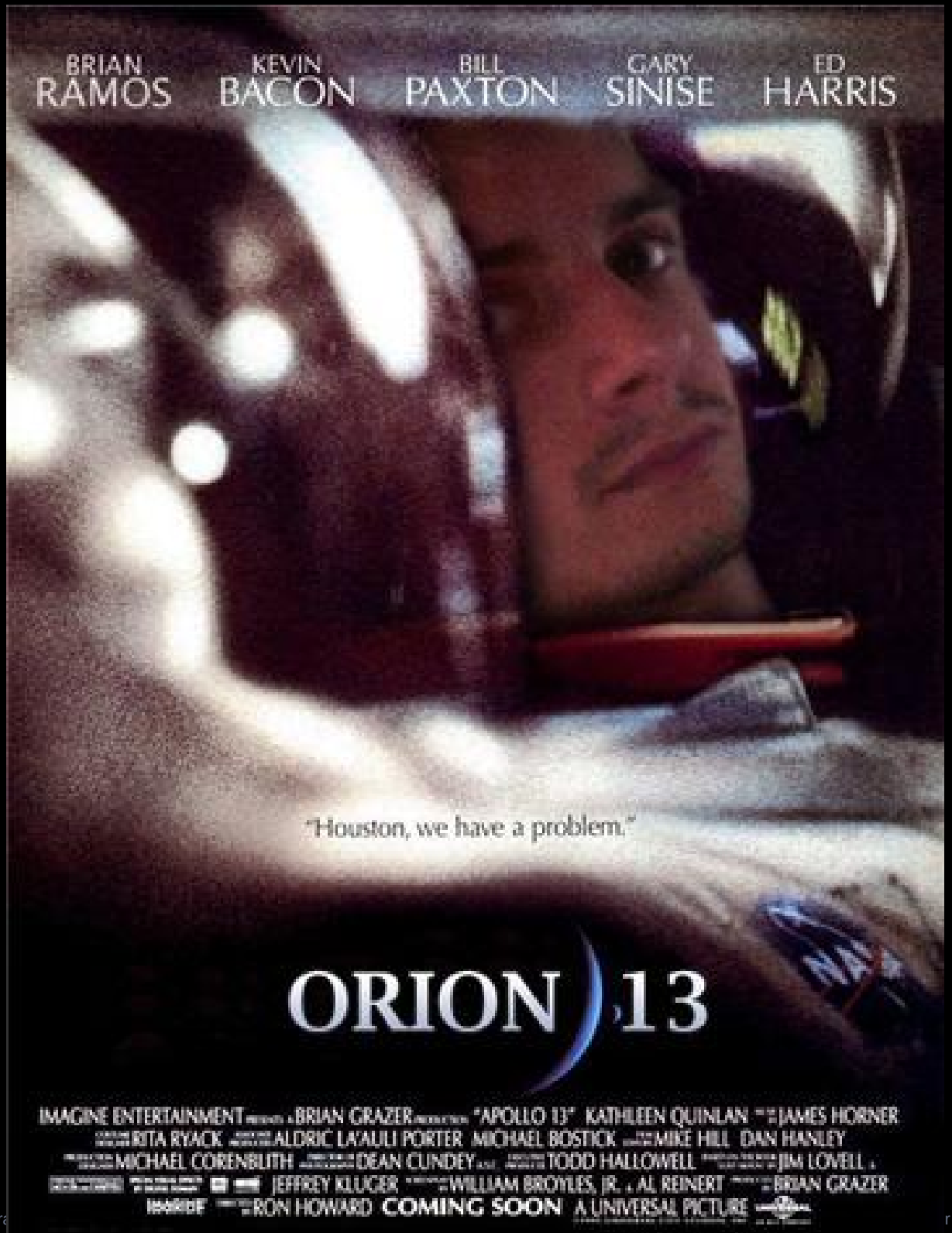
- A lot of experience with different BCI technologies
- Human factors perspective – piece of the puzzle
- User point of view and research
- Improved documentation and procedure writing skills
- Investing time
- Patience and one on one teamwork

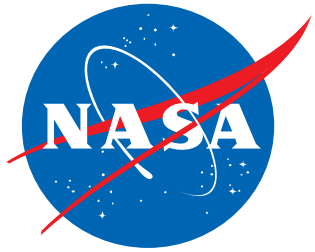
Thank you

- Mihriban Whitmore
- Lauren Merkle
- Mai Lee (Not Cyrus) Chang
- Frank Delgado
- Shelby Thompson
- Ron “Big Deal” McNeel
- Kendall Youngstrom
- All of NSBRI

Where Next

- NASA
- International Space University M.S.
- Engineering World Health
- Full-Time


BRIAN RAMOS
KEVIN BACON
BILL PAXTON
GARY SINISE
ED HARRIS
"Houston, we have a problem."
ORION 13
IMAGINE ENTERTAINMENT BRIAN GRAZER "APOLLO 13" KATHLEEN QUINLAN JAMES HORNER
RITA RYACK ALDRIC LA'AULI PORTER MICHAEL BOSTICK MIKE HILL DAN HANLEY
MICHAEL CORENBLITH DEAN CUNDEY TODD HALLOWELL JIM LOVELL
JEFFREY KLUGER WILLIAM BROYLES, JR. & AL REINERT BRIAN GRAZER
RON HOWARD COMING SOON A UNIVERSAL PICTURE


NASA

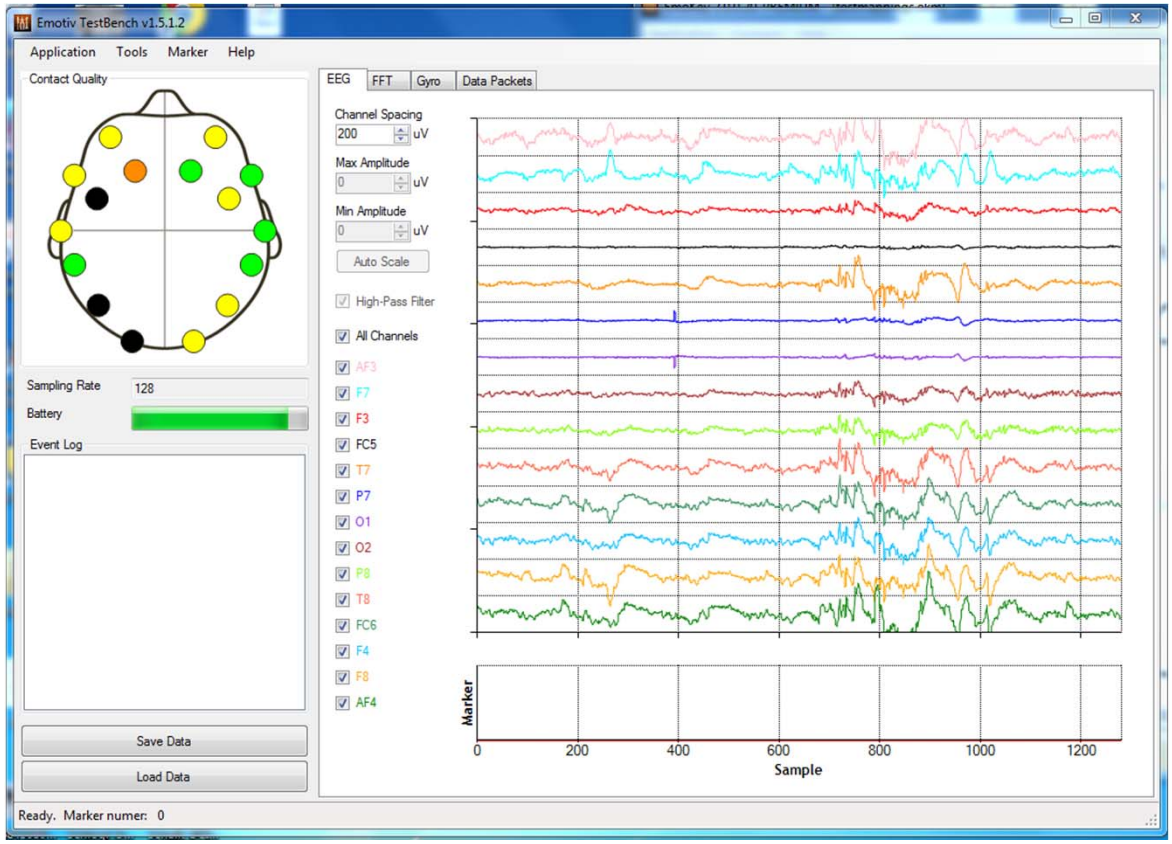
Investigating BCI

- Neurosky
  - Games
  - SDK
  - Concentration
    - Frequency range

Brainwave Type	Frequency range	Mental states and conditions
Delta	0.1Hz to 3Hz	Deep, dreamless sleep, non-REM sleep, unconscious
Theta	4Hz to 7Hz	Intuitive, creative, recall, fantasy, imaginary, dream
Alpha	8Hz to 12Hz	Relaxed, but not drowsy, tranquil, conscious
Low Beta	12Hz to 15Hz	Formerly SMR, relaxed yet focused, integrated
Midrange Beta	16Hz to 20Hz	Thinking, aware of self & surroundings
High Beta	21Hz to 30Hz	Alertness, agitation

Investigating BCI

- Emotiv
  - Expressiv Suite
  - Affectiv Suite
  - Cognitiv Suite
  - Testbench
  - Keystrokes



Investigating BCI

- Cognionics
  - EEG reader
    - Map
    - Impedance
    - Signal readout

Hobbies

Revive the Roots